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The evolution of the X-ray and radio emission of GW170817/GRB170817A

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18 days earlier: no Virgo (joined on Aug 1, 2017)
9 days after: no LIGO-Virgo (end of 02: Aug 25, 2017)
15 degrees to West: too close to the Sun for any follow-up only ~1.5 hr visibility @ beginning of the night

World-wide observational campaign

Multi-messenger Observations paper, 2017, ApJ, 848, L12



Publications on 16 October 2017:

Abbott et al. 2017, PhReL, 119, 1101; Abbott et al. 2017, ApJL, 848, L13; Alexander et al. 2017, ApJ, 848, L21; Arcavi et al. 2017, ApJ, 848, L33; Blanchard et al. 2017, ApJ, 848, L22; Chornock et al. 2017, ApJ, 848, L19; Coulter et al. 2017, Science, 10.1126, aap9811; Covino et al. 2017, Nat. Astr., 1, 791; Cowperthwaite et al. 2017, ApJ, 848, L17; Diaz et al. 2017, ApJ, 848, L29; Drout et al. 2017, Science, 10.1126, aaq0049; Goldstein et al. 2017, ApJ, 848, L14; Evans et al. 2017, Science, 10.1126, aap9580; Fong et al. 2017, ApJ, 848, L23 Haggard et al. 2017, ApJ, 848, L25; Hallinan et al. 2017, Science, 10.1126, aap9855; Hjorth et al. 2017, ApJ, 848, L31; Kasen et al. 2017, Nature 551, 80; Kasliwal et al. 2017, Science, 10.1126, aap9455; Levan et al. 2017, ApJ, 848, L28; Kilpatrick et al. 2017, Science, 10.1126, aaq0073; Margutti et al. 2017, ApJ, 848, L20; Marguia-Berthier et al. 2017, ApJ, 848, L34; McCully et al. 2017, ApJ, 848, L32; Nicholl et al. 2017, ApJ, 848, L18; Pian, D'Avanzo et al. 2017, Nature, 551, 67; Pan et al. 2017, ApJ, 848, L30; Shappe et al. 2017, Science, 10.1126, aag0186; Savchenko et al. 2017, ApJ, 848, L15; Soares-Santos et al. 2017, ApJ, 848, L16; Siebert et al. 2017, ApJ, 848, L26; Smartt et al. 2017, Nature, 551, 75; Tanvir et al. 2017, ApJ, 848, L27; Troja et al. 2017, Nature, 551, 71; Valenti et al. 2017, ApJ, 848, L24;

- + 70 papers on astro-ph between 16-18 October 2017
- ~110 published papers in the first week after the end of the embargo
- + 50 papers in the next 10 months (>5 papers/month).....and counting.....

GW170817: why so special?

Black Holes of Known Mass



Several detections of GW signals during O1 and O2

GW170817: why so special?



The first GW signal of a binary NS merger !!!

GW170817: why so special?



The dawn of multi-messenger astrophysics

EM observation components:

 (i) GW+prompt gamma-ray detection
 -> BNS merger short gamma-ray burst progenitor (see E. Bissaldi & I. Bartos talks)

(ii) an ultraviolet, optical, and infrared kilonova
 –> heavy elements formed in the Universe



GRB170817A: a faint short GRB?



- ordinary fluence and peak flux
- 100 times closer than typical GRBs observed by Fermi-GBM
- "sub-luminous" compared to the population of long/short GRBs
- 10³ 10⁶ less energetic than other short GRBs



X-rays observations





Early time upper limits with Swift/XRT and NuSTAR:

- X-ray afterglow of GRB 170817A dimmer than for typical SGRBs
- possibly consistent with the orphan afterglow scenario
- supported by Chandra observations

Late time X-rays and radio observations

Troja et al. 2017



Late time X-rays and radio observations



Credits: Chandra Press Release

Late time X-rays and radio observations





- constraints on the nature of the emission process (synchrotron)
- no constraints on the nature of the relativistic ejecta (structured jet and isotropic jet/hot cocoon?)

Evidence of a turnover in the light curve



D'Avanzo et al., 2018

Chandra detection at t=153-164 d (Haggard et al., 2018; Troja et al. 2018): still consistent with light curve flattening

Structured jet and isotropic emission both still valid !!

XMM detection at t=135 d

 opt/X-ray spectral slope unchanged w.r.t. previous epochs: no passage of the cooling frequency

 evidence for a change in the light curve slope (flattening): likely geometrical effect





What now?



in order to disentangle between different models.....some <u>results under embargo</u>!!

Conclusions

• EM follow-up campaigns for O1 and O2 very successful

- GW 170817 / GRB 170817A gave some crucial results:
- definition and consolidation of successful follow-up strategies
- first EM counterpart (at all wavelengths)
- first unambiguous observational evidence for a kilonova
- evidence for kilonovae as a heavy elements factory
- `Smoking gun' for short GRB progenitors (but is GRB 170817A a 'classical' short GRB?)
- clues on short GRB outflow geometry and properties (first observation of an off-beam afterglow? First evidence for a structured jet? First evidence for isotropic prompt emission?)

- Remnant: less massive BH or more massive NS?

 Waiting for O3 LVC run (early 2019): how many NS-NS? how many NS-BH? how many KN flavours? how many short GRB flavours?





